

## Spatial Variation in Air Ion Concentrations under different Indoor Environments

Kamlesh Singh<sup>1</sup>, Anushree Malik<sup>2</sup> and Manoneet Singh<sup>1</sup>

<sup>1</sup> Department of Humanities and Social Sciences

<sup>2</sup> Center for Rural Development and Technology,

Indian Institute of Technology Delhi, New Delhi, India-110 016

anushree@rdai.iitd.ac.in, anushree\_malik@yahoo.com

### ABSTRACT:

Air ions are the molecules that have gained or lost electrical charges. In the environment two kinds of air ions (positive and negative air ions) are present. When the molecules lose electrons they become positively charged while when they gain one or more electrons they become negatively charged. Negative Air Ions are said to be beneficial for reducing the effect of computer oriented stress, Psychological stress, asthma & bronchial disease, migraines etc. A lot of work has been done to show that the concentration of Negative Air Ions varies with the change in environmental conditions like humidity, temperature, presence of light water droplets etc. in the natural environment. However, comparatively few studies are available on the variation of NAI in indoor environments. In the present study, an attempt was made to study the variation in Negative Air Ions and Positive Air Ions concentrations under different laboratory settings at Indian Institute of Technology Delhi. Temperature, Humidity, Negative Air Ions and Positive Air Ions concentration were monitored at specified timings in different laboratories. It was found that NAI concentrations vary significantly from 26 to 751 ions/cc under different settings. On the basis of abundance of Negative Air Ions, total settings could be divided into three categories: high (200-800 ions/cc), medium (100-200 ions/cc) and low (<100 ions/cc). The results have been statistically analyzed to study variation in different parameters. An attempt has also been made to identify the settings, which cause reduction in NAI concentrations to potentially stressful levels, so that measures can be devised to reduce the occupational stress in these environments.

**Keywords:** negative air ions, positive air ions, laboratories, occupational stress

### INTRODUCTION

Term "Ion" comes from the Greek for "traveler". Ions are molecules that have gained or lost electrical charges. They are created in nature as air molecules break apart due to sunlight, radiation and moving air and water. Ions are also produced by high energy events such as an open flame or a very hot object. There are two kind of air ions present in the environment that is positive air ions (PAI) and negative air ions (NAI) when the molecule lose electrons they becomes positively charged and when gain one or more electrons they becomes negatively charged [1].

Negative ions come mainly from radioactivity and evaporating water; also from lighting, thunderstorms and forest fires contributes both +ve and -ve ions, but during fair weathers. There is wide variation in the average NAI concentration in the outdoor environment for example near the water falls (95,000 – 450,000 ions/cm<sup>3</sup>), Mountains, seashores, breezy forest (50,000 – 100,000 ions/cm<sup>3</sup>), cities (100-2000 ions/cm<sup>3</sup>), Rooms and offices (40-100 ions/cm<sup>3</sup>).

The chemical evolution of air ions, whether created naturally outdoors or artificially indoors depends on the

composition of each environment and especially on the types and concentrations of trace species [2]. The primary positive ions are N<sub>2</sub><sup>+</sup>, O<sub>2</sub><sup>+</sup>, N<sup>+</sup>, and O<sup>+</sup> they are very rapidly converted (microseconds) to protonated hydrates, while the free electrons quickly attach to oxygen to form the superoxide radical anion O<sub>2</sub><sup>-</sup>, which also can form hydrates. These intermediate species are collectively called "cluster ions" [3].

Negative Air ions are formed when free electrons becomes attached to nitrogen (N<sub>2</sub>), Carbondioxide (CO<sub>2</sub>), Oxygen (O<sub>2</sub>) , and other molecules in air. Although chemical composition of NAI depends on the air composition and age of NAI [4], super oxide (O<sub>2</sub><sup>-</sup>) accounts for approximately 95% of the negatively charged species as it is more stable than the other primary NAI's.

Secondary NAI's such as CO<sub>3</sub><sup>-</sup>, O<sub>2</sub><sup>-</sup>(H<sub>2</sub>O), and OH<sup>-</sup>(H<sub>2</sub>O) are generated by reactions between primary NAI and components in air [5-7] and Skalny et al. [5] indicate that the cluster ions O<sub>2</sub><sup>-</sup>(H<sub>2</sub>O)<sub>n</sub> and CO<sub>3</sub><sup>-</sup>(H<sub>2</sub>O)<sub>n</sub> are dominant NAI's in moist air at steady state. However, if O<sub>3</sub> and NO<sub>x</sub> exist in air, the dominant ions are NO<sub>3</sub><sup>-</sup>(HNO<sub>3</sub>)<sub>m</sub>(H<sub>2</sub>O)<sub>n</sub> [5, 8, 9]. Ions are easily destroyed

by air pollution, air conditioning and heating system and static electricity from synthetic fabrics [10].

Indoor ions live on average about 100-1000 seconds [3], before touching a surface and shorting to ground. Outdoor ions usually live longer upto several minutes.

The effect of air ions on the human organism has been the subject of much debate [10]. Research worldwide has associated lack of negative ions with a range of diseases including asthma and bronchial diseases, difficulty in breathing, aching joints, migraines, insomnia and increased susceptibility to infections. It has also been connected with depression, lethargy, anxiety, mental hospital admissions, crimes of violence. In contrast, an excess of negative ions is reputed to be associated with feelings of calmness, alertness and well being, with quicker recovery from exhausting exercise, more appetite, sounder sleep, fewer bodily aches and pains, and fewer respiratory complaints.

Modern work places, which intend to offer a great rise in human productivity are often associated with poor ambient environment leading to minor human complaints as respiratory and nasal symptoms, eye irritations, lethargy and headaches, which result in absenteeism, inefficient working and low productivity.

Among other factors affecting the quality of air, the role of air ions on the well being of people working in these environments cannot be ignored. Many research workers allege that negative air ions have stimulating and beneficial influences on human beings, particularly on ailing humans [11-14] and on ion-depleted indoor environments, while others [15-18] have been able to discern no effects.

Recent studies depict strong antimicrobial properties of NAI [19]. No harmful consequences of negative air ions have as yet been detected. Therefore, it is important to identify ion-depleted, and therefore potentially 'sick' environments so that the comfort level and efficiency of the persons working in such enclosures may be improved by appropriate interventions.

The objective of the present work was to study the variation in Negative Air Ions and Positive Air Ions concentrations under different laboratory settings at Indian Institute of Technology Delhi. It was envisaged

that based on this data, it will be possible to identify highly NAI depleted settings (with potentially stressful levels), so that measures can be devised to reduce the occupational stress in these environments.

## MATERIALS AND METHODS:

### Experimental plan

The concentrations of the negative air ions and the positive air ions in nineteen randomly selected laboratories of IIT Delhi were measured with the help of Air Ion Counter (Fig. 1) at fixed timing. The readings were taken for 30 seconds and the variations were jotted down. Their average values were then computed.

Also, the temperature and humidity values were noted for the laboratories at the time of the experiment. Details of the settings in these laboratories were also recorded.

### Air Ion Counter

The Air Ion Counter can be used for the detection of natural and artificial ions. It is an instrument through which both the positive and negative air ions are counted.

The ion counter used in present studies is shown in Fig.-1. It can count the ions in a wide range (10-1,999,000 ions/cm<sup>3</sup>) with an accuracy of  $\pm 25\%$  for fast ions (mobility greater than  $8 \times 10^{-5}$  m/s per V/m), which constitute majority of ions. It has a pretty short settling time (2 seconds) and has a noise level of about 10 ions/cm<sup>3</sup> (over a 10-second period).



Fig. 1: Air-ion counter used in the study

The Air Ion Counter pulls air (or any other gas with ions present) through a parallel plate assembly. Outer two plates are held at polarization potential (+ or -). Center is the linear detector plate. Air gap is 4mm and polarization field is 1000 V/m. To begin with the measurements, the instrument was earthed because the body of the counter should not be charged. The polarity and the measure knob were initially set at the center position (between + and -). The range knob was adjusted to 19.99 for lower range or at 199.9 & 1999 for higher range. The reading was recorded once the display became stable. To measure the positive air ion count, the switch was shifted towards the positive polarity and for negative air ion count towards the negative polarity. During ion measurements, care was taken to ensure that meter was stable (stationary) and air inlet slot was reasonably far (2 feet) from any solid object as the solid are electrically charged and alter the number of ions present in there vicinity. Also, whenever the range was changed or significant difference in temperature was sensed, the re-zero was essentially set before counting.

## Temperature and Humidity meter

A handy instrument was used to record the temperature and the relative humidity in the air.

## RESULTS AND DISCUSSION

To conduct this study various laboratories of IIT Delhi were chosen where diverse type of machinery and activities were expected. As explained earlier, the aim was to find out whether such microclimatic variations affect the ambient air ion concentrations (especially NAI). As described earlier, the readings were taken for 30 seconds and the variations were jotted down.

Their average values were then computed. Within the initial 30 seconds, some labs (example Yarn production Lab, Textile research Lab) showed higher rate of variations resulting in higher number of readings as compared to other categories where the rate of variation as well as the number of readings was less (example fabric manufacturing lab, Foundry lab). There was substantial variation in the air ion counts within the given setting or laboratory, which can be attributed to the short life span of the ions. However, when the data collected from several laboratories were compared (raw data not shown), it showed that not only mean but range of ion concentrations in different laboratories also varied considerably. Whereas, environmental factors like

humidity (Range=31-38 %) and temperature (20.4-28.7°C) did not vary much during the constant sampling timings.

It seems that factors other than humidity and temperature might be playing important role in intervening the air ion concentrations. The NAI concentrations vary significantly from 26 to 751 ions/cc under different settings. To facilitate the interpretation of these results, various laboratories of IIT Delhi were divided into 3 categories (Table 1) on the basis of abundance of Negative Air Ions i.e. high (200-800 ions/cc), medium (100-200 ions/cc) and low (<100 ions/cc) category. If we compare all three categories, there is not much variation in humidity and temperature of different categories (Figure 2a).

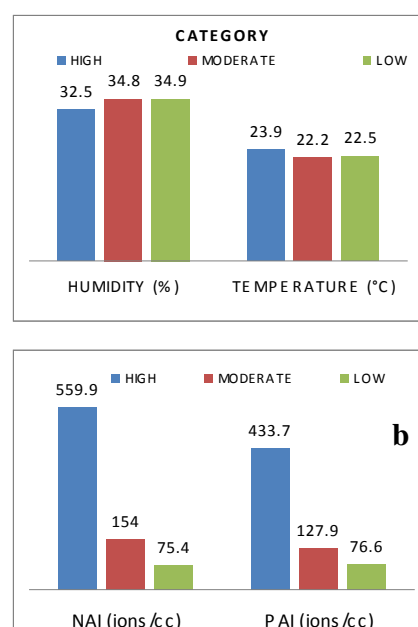


Fig. 2. Variation in (a) humidity & temperature and (b) air-ion concentrations in different categories of laboratories classified on the basis of NAI concentrations

The p value is greater than 0.05 so there is no significant difference and the null hypothesis is accepted which means that temperature and humidity do not vary in the 3 conditions. However, there is a lot of difference in these categories on NAI and PAI concentration (Fig. 2b). The value of p is less than 0.05 so the null hypothesis is rejected and it can be said that there is a significant difference between the NAI and PAI in all the 3 conditions.

Table 1: Categorization of different laboratory settings on the basis of negative air ions concentrations

	Temperature (°C)	Humidity (%)	NAI (ion/cc)	PAI (ion/cc)	Remarks on laboratory conditions
High category	23.3	35	751.48	287.41	Fully air conditioned, no work going on
	23.2	31	721.85	726.30	Soothing environment, Water and lots of chemicals present
	25.8	32	318.89	249.26	No AC, no machine working
	28.7	33	269.17	133.75	Machines present but not working at measurement time
	23.3	34	64.83	44.49	Machines present and working
	22.5	34	139.64	96.43	Machines not working, no air ventilation, darkness
	20.4	35	208.46	73.46	No machines working, soothing environment
	Range: 20.4-28.7	31-35	208.5 - 751.5	37.7-726.3	
	Mean: 23.9	32.5	559.9	433.7	
	SD: 1.8	1.62	216.4	264.7	
Medium category	20	37	185.6	148.5	Carpentry: students working
	22.6	33	158.6	110.4	Pollution control lab: no work going on, some chemicals
	22.5	34	139.6	96.4	Yarn production lab, carding machines but not working, no air ventilation, dark room
	22	36	136.5	113.1	Foundry: soil related activities
	23	35	131.3	103.9	Pg lab: dark, machines not working, no sunlight
	22	38	124.1	242.9	Blacksmith: coal burning, working with hot iron
	Range: 20-23	33-38	124.7-185.5	96.4-242.9	
	Mean: 22.02	34.8	154.0	127.9	
	SD: 1	1.86	19.18	38.05	
Low category	23.2	34	93.9	48.2	Chemical Eng. reaction lab: suffocating, air not breathable
	21.4	36	83.6	103.2	Sheet metal lab: Bad small
	20.4	37	69.6	76.8	Welding: no work going on
	23.3	34	64.8	44.5	Yarn manufacturing lab: machines working
	27	31	63.1	76.9	Textile research lab, few small machines working
	21.4	36	26.3	52.9	Computer/AC running
	Range: 20.4-27.0	31.0-37.0	26.3-93.9	44.5-103.2	
	Mean: 22.5	34.9	75.4	76.6	
	SD: 1.7	1.58	18.1	26.0	
Chi Square	5.22 (Non Sig.)	1.47 (Non Sig.)	2694.79 (Sig. at 0.001 level)	856.95 (Sig. at 0.001 level)	

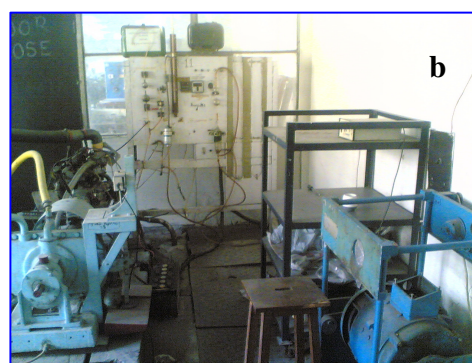


Fig. 3: Photographs showing (a) Textile Chemistry Lab with high NAI (b) PG Lab with medium NAI

It is expected that environmental factors like air ventilation; Sun light and equipments/ existing material affect NAI and PAI concentrations. Air quality is also reported to affect the ambient NAI concentration [10]. Laboratories with high negative air ions have air conditioning, soothing environment and no work was going on at the time when readings were taken.

Also, the Textile Chemistry lab, which contained a lot of water, had a very high negative air ions concentration (Figure 3a). It can be noticed that the laboratories under the medium category harbor activities such as carpentry, foundry and coal burning operations, which are expected to produce pollutants and aerosols. Similarly, the low category laboratories have metal related activities such as welding while others have suffocating, polluted environment filled with dust, flying fibres and lack of air and sunlight. It seems that the PG lab (Figure 3b) had a lower concentration of negative air ions concentration due to these reasons. It was observed that the computer lab had the least concentration of negative air ions.

It is expected in the present study that there are various reasons, for instance, air ventilation, sun light, nature of material, working conditions etc. affecting concentration of NAI and PAI in different settings. Lajcikova, Mathauserova & Bencko [20] gave a practical interpretation and recommendation of suitable materials into interior spaces in view of the protection of natural air ionization, and the study also assessed the effects of ambient temperature, humidity and air ionization in an office environment on the rating of thermal comfort, stuffiness, alertness, well-being and other subjective responses.

Hawkins [21] observed the reasons for low air ion levels in indoors settings like Electrostatic filters, low humidity, static charges build up on carpets, furniture, wall fabrics, workers' clothing and electrical equipment such as VDU screens, Smoke and contamination and High density of individuals.

Our results also indicate that several parameters affect the NAI concentration and it shall be possible to identify suitable conditions with respect to desirable NAI counts after thorough investigations. Further, in the present study, data was collected within 15 days, so study has no effect of seasonal variation in NAI and PAI concentration in different settings. Since, there is dearth of such researches especially in India, the present study opens mode of further researches in this area.

Recommendations: Seasonal and day timing variation could be studied further in Indian climatic conditions. The present study gives overall variation of laboratories NAI and PAI concentrations, there is need to do further research at micro level having minute observations of existing material and about how and why it is facilitating / inhibiting air ionization. Furthermore, how the effects of low levels of negative ions can be counteracted, as several researches have documented that it has negative effect on our physical and psychological well-being.

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## REFERENCES:

- [1] Soyka F., Edmonds A. (1977) The ion effect: How air electricity rules your life and health. New York: E. P. Dutton & Co., Inc., p.181
- [2] Comita P.B., Brauman J.I. (1985) Gas phase ion chemistry, *Science*, (227): 863-869.
- [3] Stalcy L., Daniel S. (2002). On the ionization of air for removal of noxious effluvia, *IEEE Transactions on Plasma Science*, 30: 1471-1481.
- [4] Parts T.E., Luts A. (2004) Observed and simulated effects of certain pollutants on small air ion spectra: I. Positive ions, *Atmos Environ* 38: 1283-1289.
- [5] Skalny J.D. et al, (2004) Ozone generation in a negative corona discharge fed with N<sub>2</sub>O and O<sub>2</sub>, *J. Phys. D: Appl. Phys.* 37 : 1052-1057.
- [6] Huertas M.L., Fontan J., Gonzalez J., (1978). Evolution times of tropospheric negative ions, *Atmos Environ*. 12: 2351-2362
- [7] Luts A. (1995) Evolution of negative small ions at enhanced ionization, *J. Geophys. Res.* 100: 1487-1496.
- [8] Luts A., Salm J. (1994) Chemical composition of small atmospheric ions near the ground, *J. Geophysical Res.* 99: 10781-10786.
- [9] Perkins M.D., Eisele F.L. (1984) First mass spectrometric measurements of atmospheric ions at ground level, *J. Geophys. Res.* 89: 9649-9657.
- [10] Krueger A. P., Sfgel S. (1978) Ions in the air. *Human Nature*, 1: 46-52.
- [11] David T.A., Minehart J.R., Kornblueh I.H., (1960) Polarised air as an adjunct in the treatment of burns, *American J. Physical Medicine*, 39: 111.

- [12] Krueger A.P. (1962) Air ions and physiological function, *J.General Physiol.*, 45: 233-241.
- [13] Palti Y., Denour E., Abramov A. (1966) The effect of atmospheric ions on the respiratory systems of infants, *Pediatrics*, 38: 405-411.
- [14] Assael M., Pfeifer Y., Sulman F.G., Alpern S., Shaliota B., (1974) The influence of artificial air ionisation on the human electroencephalogram, *Int. J. BioMeteorol.*, 18:306-312
- [15] Erban L. (1959) A study of biochemical and haematological changes under the application of ionised air, *Int. J. Bioclimatol. Biometeorol.*, III, IV.
- [16] Chiles W.D., Cleveland J.M., Fox R.E. (1960) A study of the effects of ionised air on behaviour, WAAD Technical Report 60 598, Contract No. A.F. 33[616-5839], Physical Eng. and Chemistry Corp.,
- [17] Fishman D. (1981) Subjective comfort associated with negative air ions, *The Heating and Ventilation Engineer*, 115, 13-15.
- [18] Hedge A., Eleftherakis E. (1982) Air ionisation: an evaluation of its physiological and psychological effects, *Annals of Occupational Hygiene*, 25: 409-410.
- [19] Kumar A., Nirala B. K., Malik A., Singh K. (2008) Sensitivity of *Escherichia coli* and *Pseudomonas* Fluorescence to Negative Air Ion Exposure, *J. Environ. Sci. Health*, A43: 694-699.
- [20] Lajčíková A., Mathauserová Z., Bencko V. (1999) Electro-ionic microclimate and materials used in the indoor environment, *Central European J Public Health*, 7: 15-18.
- [21] Hawkins L. H. (1985) Biological significance of air ions. *Proc. IEE Colloquium on ions in the atmosphere, natural and man made.* London, UK, 1985. BLL Conf Ind. 3315.470 No 88